

RESULTS FROM CSMW TASK 3

(Beach Nourishment Projects – Performance and Sediment Characteristics)

TASK 3 – Compile known and available information on: the types and grain size distribution of sands that have been used for nourishment projects along the important California beaches; observed end results of nourishment projects; the basis for limitation placed on the percentage of allowable finer grained materials in nourishment projects. Include any information gathered on existing grain size distributions at those important beaches.

BACKGROUND

There are many variables that affect the success or failure of beach replenishment/nourishment projects. One of the main criteria for defining the “success” of such projects is the longevity of the “fill,” or borrow material, placed during individual episodes of nourishment. For example, given a volume of fill emplaced in a beach system, managers and engineers want to know what percentage of that fill is retained in the littoral cell after a given period of time. How a fill performs with time is a function of the interaction of several conditions and properties. Some of these include local wave and current conditions; technique and location of fill placement; and the reliability of the monitoring method. The interactions will determine if a fill remains in the system longer or shorter than expected.

One property of interest in the performance of fills is the physical compatibility between the fill material and the “native” material of the beach where the fill is to be placed. “Compatibility” refers to the degree of similarity of the two materials and includes the size, type (mineralogy), color, density, and shape of the component sediment grains. Typically, size is the most commonly evaluated in trying to match a fill material with a native material mainly because of its potential mechanical performance within the dynamics of the beach environment. Grain type and color can locally be important because of aesthetic or health/safety concerns. A textbook on beach nourishment and protection published by the National Research Council (1995) presents a brief discussion of sand compatibility; various papers are cited that discuss the pros and cons of continued use of grain-size comparisons between fill and native materials as measures of beach performance. Also, the Coastal Engineering Manual (U.S. Army Corps of Engineers, 2002) has sections on beach-fill design and performance.

There are three main concerns with grain size. First, if the percentage of fines (clay- and silt-sized grains) in the fill is too high, a correspondingly larger volume of fill material must be emplaced in the beach system to allow for loss of the fines with time caused by winnowing action of the waves. Second, too high of a percentage of fines in a beach sand is recreationally undesirable – there may be clumping of the material, for example.

Third, fines can harbor or attract contaminants, which may be hazardous to humans and sea life; placement of a contaminated material on a beach system can be detrimental.

Beach Replenishment/Nourishment in California

Beach replenishment/nourishment began in California at least as early as 1919 (Coyne, 2000). Several hundred episodes of replenishment and periodic nourishment have occurred at several dozen beach systems along the coast. Most of these have been in southern California, particularly in the Santa Barbara and Ventura areas, and along the coastlines of Santa Monica Bay, Orange County, and San Diego County.

Currently (2004), there is reportedly only one beach replenishment/nourishment project currently underway in the San Francisco District of the U.S. Army Corps of Engineers, which extends from the Oregon border to just north of the San Luis Obispo-Monterey County line. This project consists of disposal of dredge material at Ocean Beach in San Francisco. In the Los Angeles District, which covers the remainder of the coast to the Mexico border, there are many on-going projects. Some are related to harbor maintenance: those at Santa Barbara, Ventura, Channel Islands, and Oceanside are done annually, while those at Morro Bay, Playa del Rey, and Mission Beach are done infrequently. As an example unrelated to disposal of dredged material, nourishment was recently accomplished at Goleta in Santa Barbara County.

Tracking the history and performance of these projects and individual episodes of replenishment/nourishment is a challenge largely because of the inconsistent documentation and because the information is commonly in unpublished files or reports. Through sponsorship of the California Coastal Commission and California Department of Boating and Waterways, Melanie Coyne, a National Oceanographic and Atmospheric Administration (NOAA) Fellow, researched and compiled the most comprehensive list of beach nourishment projects along the coast of California (Coyne, 2000). Presented here in modified form as Table 2, this list covered projects up to the year 2000. Also included here as Table 3 is Coyne's list of references that she consulted to compile the data and information. As an update to the list since 2000, we have added the individual replenishment/nourishment episodes of the SANDAG Regional Beach Sand Project as documented by Coastal Frontiers Corporation (2004).

Historically, most of the replenishment/nourishment activities in California have been pursued as local, rather than regional, projects. They have been dominantly "opportunistic" projects, meaning that beach restoration was not the primary purpose of the placement of fill. Rather, the beach systems were the receiving (disposal) sites for dredged material from other primary activities such as harbor construction or channel maintenance. Only in recent years has the number of "deterministic" projects become more common. In these projects, beach restoration through replenishment and nourishment is the primary purpose. The recently instituted Regional Beach Sand Project of the San Diego Association of Governments (SANDAG) is the first regional deterministic beach-nourishment program on the Pacific Coast of the United States.

CHARACTER OF FILL MATERIAL AND NATIVE MATERIAL

Data and information on the physical character of sediment involved in beach replenishment/nourishment projects along the coast of California range from sparse to well-documented. One of the main influences on documentation is whether a project is deterministic or opportunistic. Deterministic projects generally have greater testing of materials because of regulatory or economic considerations and requirements; the fill materials are commonly taken for a fee from virgin sources, which have unknown or poorly known characteristics. In contrast, testing is commonly less rigorous in opportunistic projects, particularly if a source for the fill material has been used previously and there are few or no reported problems of compatibility with the native material. The receiver beaches are generally very close to the sources of fill (e.g., bypassing operations) because of the desire to minimize transportation costs. Consequently, the fill material may be very similar in character to what would have been deposited naturally at the receiver beach.

Another factor that affects documentation of the physical character of sediment is the age of the projects. Older projects were under less regulation and thus may not have the quantity and quality of test data like those of modern projects.

Types of information reported for replenishment/nourishment projects can include size, type, color, density, and shape of the component grains. Grain size is by far the most dominant characteristic analyzed and reported; results are typically presented as percentage distribution of sizes within each sediment sample based on sieve analysis. In some reports, the percentage composition by mineral type is presented.

Regarding the character of native material on beaches, many pure- and applied-research studies have been conducted at several sites along the coast of California. Some of these studies are published and thus readily available (e.g., Hutton, 1959; Trask, 1952). Other sources include more-obscure or less-easily obtained reports (e.g., Straughan, 1981; reports of the Hydraulic Engineering Laboratory at the University of California, Berkeley). As a group, this category of studies is neither systematic nor consistent in content and presentation because of differences in researchers' purposes and interests. Nonetheless, they can provide background and baseline information, particularly at beaches that have not yet been replenished.

Regarding the character of both fill materials and native materials, much data and information are also available in geotechnical reports prepared for specific replenishment/nourishment projects. For example, data on grain characteristics are commonly presented in documents, such as environmental impact reports, submitted to the California Coastal Commission as part of its permit process. Also, the U.S. Army Corps of Engineers conducts detailed sampling and analyses of sediments, which are presented in its geotechnical reports (e.g., U.S. Army Corps of Engineers, 1989; 1995; 2002b). Some of its reports are readily available, while others are not; some reside in

the project files of the geotechnical branches of both the Los Angeles and San Francisco District offices, while others are at archive centers in Laguna Niguel (Los Angeles District) and San Bruno (San Francisco District).

The character of fill material and, to a much lesser extent, native material at some of the replenishment/nourishment projects in California is summarized in Table 2 (modified from Coyne, 2000) under the column heading of “dredge/fill characteristics.” These entries were extracted from research of a few hundred reports. Most are qualitative descriptions rather than quantitative data.

It is worth noting that at many southern California beaches (Santa Barbara County to the Mexico border) there is probably not much truly pristine, “native” material still present. Episodes of nourishment have diluted the original natural character of the beaches, particularly where nourishment has taken place frequently over many decades. Also, because of the inherent variability in the physical nature of natural sediments, it is difficult to generalize or define representative grain characteristics for individual beaches and fill material.

To prepare a comprehensive list of grain characteristics of fill material and native material will require systematic, detailed research of published literature as well as unpublished reports and files in agencies such as the U.S. Army Corps of Engineers and the California Coastal Commission, among others.

RESULTS OF BEACH REPLENISHMENT/NOURISHMENT IN CALIFORNIA

Of paramount importance in a replenishment/nourishment project is how well the emplace material performs compared to the engineering specifications of the project. To make reliable comparisons requires the use of systematic, quantitative monitoring of the performance of beach fills. Unfortunately, it was not until about 10-20 years ago that monitoring became more routine (Leonard and others, 1989; Komar, 1997). Up to the end of the 1980s, performance data for projects on the Pacific Coast of the U.S. were less prevalent than for those for the Atlantic Coast (Leonard and others, 1989). Since then, agencies in California have been taking more coordinated, regional approaches to protecting beaches. Part of this process has been institution of monitoring programs. One example is the Regional Beach Monitoring Program of the San Diego Association of Governments (SANDAG), which began in the middle 1990s (Coastal Frontiers Corporation, 2004). Associated with this project is the Southern California Beach Processes Study (Guza and others, 2002) at Torrey Pines State Beach, which is attempting to improve understanding of how and where a recent beach fill there is being transported by waves and currents. What is learned here could be applied to design and maintenance of replenishment/nourishment projects else where along the coast of California.

Historically, written documentation of the results of beach replenishment/nourishment projects along the coast of California has been inconsistent. Commonly, results have

been reported from a site-specific perspective, with an emphasis on qualitative rather than quantitative observation and measurement. Examples are presented in Cahill (1989), Clayton (1989), Leonard and others (1989), Leidersdorf and others (1993, 1994), Mesa (1996), California Department of Boating and Waterways and State Coastal Conservancy (2002), U.S. Army Corps of Engineers (2002b), and Coastal Frontiers Corporation (2004). Important overview papers for results and performance in California include those by Hall (1952), Shaw (1980), Herron (1987), Clayton (1989), and Leonard and others (1989).

The performance of beach fills at various sites in the state is briefly summarized in Table 2 (modified from Coyne, 2000) under the column heading “duration of fill.” Similar to the entries in the table for “fill characteristics” described earlier, the reported results are largely qualitative descriptions rather than quantitative measurements. Many cells in this column are blank, either because monitoring was not conducted or because the research did not discover pertinent documents with recorded results.

To date, the overall results of beach nourishment in California have been mixed. As a current example of performance and monitoring of beach fills, Coastal Frontiers Corporation (2004) recently reported results of monitoring of a major nourishment program in San Diego County. In this program, administered by the San Diego Association of Governments, twelve beaches received nourishment in 2001. During the 2003 monitoring year, the performance of the individual fills at the twelve beaches reportedly varied considerably; at some beaches, previous gains in shorezone volumes persisted, while at others, the gains were short-lived.

Despite the spotty record of documented results of replenishment/nourishment projects in California, Leonard and others (1989) attempted to determine the overall success of various projects as of the late 1980s. As part of this determination, they also evaluated how five physical parameters might influence the success of fill episodes as measured by longevity, or “durability,” of the emplaced fills. Some of their major conclusions for Pacific Coast beaches (nearly all are evidently in southern California) were:

- Longevity of fills at Pacific Coast beaches has overall been higher than those at Atlantic Coast and Gulf Coast beaches.
- Of those beaches measured, 48% were successfully maintained, 15% were not, and 36% were unknown.
- The Pacific Coast management philosophy of nourishment by periodic “maintenance” was advantageous over the Atlantic/Gulf Coast management philosophy of nourishment by “crisis.”
- Project monitoring must be a mandatory part of each replenishment project.

Regarding replenishment parameters:

- **Length:** There was no relationship between longevity of replenished beaches and their lengths.
- **Density:** Pacific Coast beaches had higher cumulative densities of fill than Atlantic Coast and Gulf Coast beaches. For the Pacific Coast, there didn't appear to be a correlation between fill density and fill durability.
- **Grain Size:** The data suggested that grain size was not of particular importance in determining durability.
- **Groins:** These structures have aided stabilization of certain nourished beaches on the Pacific Coast.
- **Storms:** There was a correlation between high erosion rates on nourished beaches of the Pacific Coast and the passage of major storms.

RECOMMENDATIONS

- With some editing and modification, use Coyne's (2000) spreadsheet (Table 2) as a foundation to annually compile data and information on all beach replenishment/nourishment projects along the coast of California. Georeference this table so that it can be incorporated into the GIS of the CSMW Master Plan.
- Determine if the influence of grain-size on fill performance is significant enough to devote CSMW resources to the task of compiling detailed data on grain-size characteristics of fill materials and native materials for beach-nourishment projects along the coast of California.

CSMW TASK THREE

Bibliography

GENERAL

D'Angremond, K., De Jong, A.J., and Van Oorschot, J.H., 1988, Beach replenishment - design elements and implementation: *Terra et Aqua*, no. 37, p. 19 - 27.

Davison, A.T., Nocholls, R.J., and Leatherman, S.P., 1992, Beach nourishment as a coastal management tool: an annotated bibliography on developments associated with the artificial nourishment of beaches: *Journal of Coastal Research*, v. 8, no. 4, p. 984 - 1022.

Dean, R.G., 1974, Compatibility of borrow material for beach fills: American Society of Civil Engineers, Proceedings of the 14th Coastal Engineering Conference, p. 1319-1330. *Compatibility*.

Dean, R.G., 1983, Principles of beach nourishment, *in* Komar, P.D., editor, CRC handbook of coastal processes and erosion: CRC Press, Boca Raton, Florida, p. 217-232. *Compatibility*.

Dean, R.G., 1988, Managing sand and preserving shorelines: *Oceanus*, vol. 31, p. 49-55.

Dean, R.G., 2003, Beach nourishment: Theory and practice: World Scientific Publishing Company, River Edge, New Jersey, 420 p.

Dean, R.G., and Abramian, J., 1993, Rational techniques for evaluating the potential of sands for beach nourishment: U.S. Army Corps of Engineers, Coastal Engineering Research Center Technical Report CERC-DRP-93-2, 179 p.

Dean, R.G. and Dalrymple, R.A., 2004, Coastal processes with engineering applications: Cambridge University Press, 487 p.

Dette, H.H., 1977, Effectiveness of beach deposit nourishment: American Society of Civil Engineers, Coastal Sediments '77, p. 211-227.

Eitner, V., 1996, The effect of sedimentary texture on beach fill longevity: *Journal of Coastal Research*, v. 12, p. 447-461. *Compatibility*.

Garland, G.G., 1990, Sand mass density and borrow material compatibility for beach nourishment: *Ocean and Shoreline Management*, v. 23, no. 2, p. 89-98.

Giordano, A., and Rowland, J., 1999, Use of federal sand for beach nourishment and shore protection projects: *Marine Georesources and Geotechnology*, v. 17, no. 2-3, p. 91 - 97.

Giordano, A.C., 1993, Coastal states marine mining laws: U.S. Dept. of the Interior, Minerals Management Service OCS Report MMS 93-0063, 48 p.

Houston, J.R., 1991, Beachfill performance: *Shore & Beach*, v. 59, p. 15-24.

Houston, J.R., 1995, Beach nourishment: *Shore & Beach*, v. 63, no. 1, p. 21-24.

Houston, J.R., 2000, Beach and coastal restoration: *World Dredging – Mining and Construction*, v. 36, no. 2, p. 6-7, 14-15, 20.

James, W.R., 1974, Beach fill stability and borrow material texture: American Society of Civil Engineers, Proceedings of the 14th Coastal Engineering Conference, p. 1334-1349.

James, W.R., 1975, Techniques in evaluating suitability of borrow material for beach nourishment: U.S. Army Corps of Engineers Technical Memorandum 60, p. 95-102.

Komar, P.D., 1997, Beach processes and sedimentation: Prentice Hall, Upper Saddle River, New Jersey, 2nd edition, 544 p.

Krumbein, W.C. and James, W.R., 1965, A lognormal size distribution model for estimating stability of beach fill material: U.S. Army Corps of Engineers Technical Memorandum 16.

Mugler, M.W., 1981, Beach nourishment with dredged material: U.S. Army Engineer Institute for Water Resources Policy Study 81-0110, 66 p.

National Academy Press, 1990, Managing coastal erosion: National Academy Press, Washington, D.C., 182 p. *Has short discussion of sand compatibility.*

National Research Council, 1995, Beach nourishment and protection: Washington, D.C., National Academy Press, 334 p.

Pilkey, O.H., 1990, A time to look back at beach nourishment: *Journal of Coastal Research* (editorial), v. 6, p. iii-vii.

Pilkey, O.H. and Clayton, T.D., 1989, Summary of beach replenishment experience on U.S. East Coast barrier islands: *Journal of Coastal Research*, v. 5, p. 147-159.

Ramsey, K.W., 1999, Beach sand textures from the Atlantic coast of Delaware: Delaware Geological Survey Open-File Report 41, 6 p.

Rosen, D.S., 2000, Geotechnical aspects of beach restoration: Geological Society of America Abstracts with Programs, Southeastern Section, v. 32, no. 2, p. 70.

Schorr, H.R., Jr., 2001, Beach nourishment: World Dredging, Mining and Construction, v. 37, no. 2, p. 10-11, 24-25.

Smith, A.W.S., 1992, Description of beach sands: Shore and Beach, v. 60, no. 3, p. 23-30.

Stauble, D.K., 1991, Recommended physical data collection program for beach nourishment projects: U.S. Army Engineer Waterways Experiment Station CETN II-26, 14 p.

Stauble, D.K. and Grosskopf, W.G., 1993, Monitoring project response to storms: Ocean City, Maryland, beach fill: Shore & Beach, v. 61, no. 1, p. 22-33.

Stauble, D.K., and Holem, G.W., 1991, Long term assessment of beach nourishment project performance, *in* Symposium on Coastal and Ocean Management, 7th, Coastal Zone '91, Long Beach, CA, American Society of Civil Engineers, p. 510-524.

Stauble, D.K., and Kraus N.C., editors, 1993, Beach nourishment engineering and management considerations, *in* Coastlines of the World Series, Coastal Zone '93, American Society of Civil Engineers, 245 p.

Stauble, D.K., and Nelson, W.G., 1985, Guidelines for beach nourishment: A necessity for project management, *in* Symposium on Coastal and Ocean Management, 4th, Coastal Zone '85, Baltimore, MD, American Society of Civil Engineers, p. 1002-1021.

Swart, D.H., 1991, Beach nourishment and particle size effects: Coastal Engineering, v. 16, p. 61-81.

Trembaniz, A.C., Valverde, H.R., Haddad, T.C., O'Brien, M.K., and Pilkey, O.H., 1998, The U.S. national beach nourishment experience [abs.]: Journal of Coastal Research, Special Issue 26, p. A29.

U.S. Army Corps of Engineers, 1984, Shore protection manual: U.S. Army Corps of Engineers, Coastal Engineering Research Center Publication No. 008-002-00218-9, 4th edition, two volumes, 1,262 p.

U.S. Army Corps of Engineers, 1995, Design of beach fills: U.S. Army Corps of Engineers Engineering Manual 1110-2-3301, 86 p.

U.S. Army Corps of Engineers, 2002, Coastal Engineering Manual: U.S. Army Corps of Engineers Engineer Manual 1110-2-1100, Washington, D.C., 6 volumes.
(<http://bigfoot.wes.army.mil/cem001.html>)

Wiegel, R.L., 1992, Beach nourishment, sand by-passing, artificial beaches: Bibliography of articles in the ASBPA Journal Shore and Beach: Shore & Beach, v. 60, no. 3, p. 3 - 5.

COAST OF CALIFORNIA

Andrassy, C.J., 1991, Monitoring of a nearshore disposal mound at Silver Strand State Park: American Society of Civil Engineers, Coastal Sediment '91, p. 1970-1984.

Anonymous, 2000, Restoration of southern California's beaches: World Dredging - Mining and Construction, v. 36, no. 2, p. 8 - 9, 16.

Asmon, E., 1960, Heavy minerals of southern California: Ph.D dissertation, University of Southern California, 98 p.

Bowen, A.J. and Inman, D.L., 1966, Budget of littoral sands in the vicinity of Point Arguello: U.S. Army Corps of Engineers, Coastal Engineering Research Center, Technical Memorandum 19, 41 p.

Cahill, J.J. and others, 1989, Beach nourishment with fine sand at Carlsbad, California, *in* Magoon, O.T. and others, editors, Coastal Zone '89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 2092-2103.

California Department of Boating and Waterways and State Coastal Conservancy, 2002, California beach restoration study: Sacramento, California.
(www.dbw.ca.gov/beachreport.htm)

California Department of Navigation and Ocean Development, 1977, Study of beach nourishment along the southern California coastline: California Department of Navigation and Ocean Development, 151 p.

Chambers Group, Inc., 1992, Final environmental impact report/environmental assessment for the BEACON beach nourishment demonstration project: Beach Erosion Authority for Central Operations and Nourishment, SCH No. 91011072.

Clayton, T., 1989, Artificial beach replenishment on the U.S. Pacific shore – A brief overview, *in* Magoon, O.T. and others, editors, Coastal Zone '89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 2033-2045.

Coastal Frontiers Corporation, 1992, Historical changes in the beaches of Los Angeles County, Malaga Cove to Topanga Canyon, 1935-1990: County of Los Angeles, Department of Beaches and Harbors, 105 p.

Coastal Frontiers Corporation, 2004, SANDAG 2003 regional beach monitoring program: Annual Report prepared for San Diego Association of Governments by Coastal Frontiers Corporation, Chatsworth, California, 122 p.

Comellick, R.A., 1976, Petrology and economic value of beach sand from southern Monterey Bay, California: M.S. thesis, University of Southern California, 73 p.

Coyne, M., 2000, California beach nourishment history: California Coastal Commission and California Department of Boating and Waterways, unpublished spreadsheet of compiled data on beach nourishment projects in California.

Domurat, G.W. and others, 1979, Beach erosion control study, Ocean Beach, San Francisco: *Shore & Beach*, v. 47, no. 4, p. 20-32.

Dunham, J.W., 1965, Use of long groins as artificial headlands: American Society of Civil Engineers, Coastal Engineering, Santa Barbara Specialty Conference, p. 755-762.

Everts, C.H. and Eldon, C., 2000, Beach retention structures and wide sandy beaches in southern California: *Shore & Beach*, v. 68, no. 3, p. 11-22.

Flick, R.E., 1993, The myth and reality of southern California beaches: *Shore and Beach*, v. 61, p. 3-13.

Gadd, P.E., and Eschen, D.L., 1999, Low cost sand re-nourishment to combat chronic beach erosion, Long Beach, California, *in* Bringing Back the Beaches, Sand Rights '99, Ventura, CA, 1999, American Society of Civil Engineers, p. 152-160.

Gorsline, D.S., Mineral composition of river, beach and shelf sands from Point Conception to the Mexican border: Geological Society of America Special Paper 121, p. 115.

Guza, R.T. and others, 2002, Southern California beach processes study: Scripps Institution of Oceanography, 7th Quarterly Report, November 30, 2002. (<http://cdip.ucsd.edu>).

Hall, J., Jr., 1952, Artificially constructed and nourished beaches: American Society of Civil Engineers, Coastal Engineering 1952 Proceedings, Chapter 10, p. 119-133.

Hamilton, M., 1998, Grains of sand – GPS survey-grade technology provides critical data to understanding beach erosion: *Earth Observation Magazine*, vol. 7, no. 4, p. 12-14.

Handin, J.W., 1951, The source, transportation, and deposition of beach sediment in southern California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 22, 113 p.

Hands, E.B. and Allison, M.C., 1991, Mound migration in deeper water and methods of categorizing active and stable berms: American Society of Civil Engineers, Coastal Sediments '91, p. 1985-1999. *Results of nourishment at Santa Barbara*.

Herron, W.J., 1987, Sand replenishment in southern California: Shore & Beach, v. 55, nos. 3-4.

Hutton, C.O., 1952, Accessory mineral studies of some California beach sands: U.S. Atomic Energy Commission, RMO-981, 112 p.

Hutton, C.O., 1959, Mineralogy of beach sands between Half Moon and Monterey bays, California: California Division of Mines Special Report 59, 32 p.

Inman, D.L., 1953, Areal and seasonal variations in beach and nearshore sediments at La Jolla, California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 39, 134 p.

Jantz, S., Webb, C.K., and Lindquist, A.-L., 1999, Opportunistic beach fill program, Carlsbad, California: Shore & Beach, v. 67, no. 2/3, p. 44 - 49.

Judge, C.W., 1970, Heavy minerals in beach and stream sediments as indicators of shore processes between Monterey and Los Angeles, California: U.S. Army Corps of Engineers Coastal Engineering Research Center, Technical Memorandum 33, 44 p.

Knur, R.T. and Kim, Y.C., 1999, Historical sediment budget analysis along the Malibu coastline, *in* Sand Rights '99-Bringing Back the Beaches: American Society of Civil Engineers, Ventura, California, 292 p.

Leidersdorf, C.B. and others, 1993, Beach enhancement through nourishment and compartmentalization: The recent history of Santa Monica Bay: American Shore and Beach Preservation Association, Proceedings, 8th Annual Symposium on Coastal and Ocean Management, p.71-85.

Leidersdorf, C.B. and others, 1994, Human intervention with the beaches of Santa Monica Bay, California: Shore & Beach, v. 62, no. 3, p. 29-38.

Leonard, L. and others, 1989, U.S. beach replenishment experience – A comparison of the Atlantic, Pacific, and Gulf Coasts, *in* Magoon, O.T. and others, editors, Coastal Zone '89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 1994-2006.

Lilly, K., and Kingery, D., 1998, Ocean Beach, San Francisco: Protection and management of an eroding shoreline, *in* Ewing, L., and Sherman, D., eds., California's coastal natural hazards: Santa Barbara, California, University of southern California Sea Grant program, p. 106-131.

Luepke, G., 1994, Variations in titanium and chromium concentrations in magnetite separates from beach and offshore separates, San Francisco and San Mateo counties, California: U.S. Geological Survey Open-File Report 95-15, 6 p.

Mesa, C., 1996, Nearshore berm performance at Newport Beach, California, USA: American Society of Civil Engineers, Proceedings, 25th International Conference on Coastal Engineering, p.4636-4649.

Moffatt and Nichol Engineers, 1982, Balboa Island beach replenishment study: City of Newport Beach, Public Works Department, 31 p.

Moffatt and Nichol Engineers and others, 2001, Regional beach sand retention strategy: Final Report prepared for San Diego Area Governments.

Moore, D.B., 1965, Recent coastal sediments, Double Point to Point San Pedro, California: M.A. thesis, University of California, Berkeley, 86 p.

Noble, R., 2002, Beach nourishment construction at twelve San Diego County, California receiver beach sites: World Dredging, Mining and Construction Magazine, v. 38, no. 2, p. 7-20.

Noble Consultants, 1989, Coastal sand management plan, Santa Barbara/Ventura County coastline: Main Report, Prepared for Beach Erosion Authority for Control Operations and Nourishment (BEACON), 186 p.

Noble Consultants, 2000, California shoreline protection survey 2000: Report prepared for California Department of Boating and Waterways, 13 p. plus appendix (37 p.).

Page, G.B., 1950, Beach erosion and composition of sand dunes, Playa del Rey-El Segundo area, California: M.S. thesis, University of California, Los Angeles.

Parr, T., Diener, D. and Lacy, S., 1978, Effects of beach replenishment on the nearshore sand fauna at Imperial Beach, California: U.S. Army Corps of Engineers, Coastal Engineering Research Center, Miscellaneous Report 78-4, 125 p.

Patterson, D.R. and Young, D.T., 1989, Monitoring the beach nourishment project at Surfside-Sunset Beach, *in* Magoon, O.T. and others, editors, Coastal Zone '89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 1963-1977.

Pollard, D.D., 1979, The source and distribution of beach sediments, Santa Barbara County, California: Ph.D. dissertation, University of California, Santa Barbara, California, 245 p.

Powers, M.G., 1991, A regional approach to beach erosion in California: Formation, organization, and operation of B.E.A.C.O.N.: American Society of Civil Engineers, Proceedings of The Coastal Zone Experience, Coastal Zone '91, p. 187-197.

San Diego Association of Governments, 1993, Shoreline preservation strategy for the San Diego region: San Diego Association of Governments, 43 p.

San Diego Association of Governments, 1995, Shoreline preservation strategy for the San Diego region: Shore & Beach, v. 63, no. 2, p. 17-30.

San Diego Association of Governments, 2000, San Diego regional beach sand project, Draft Environmental Impact Report/Review Environmental Assessment: San Diego Association of Governments, SCH No. 1999041104.

Shaw, M. J., 1980, Artificial sediment transport and structures in coastal Southern California: University of California, San Diego, Scripps Institution of Oceanography, SIO Ref. No. 80-41, 109 p.

Straughan, D., 1981, Inventory of the natural resources of sandy beaches in southern California: Allan Hancock Foundation Technical Report No. 6, Institute for Marine and Coastal Studies, University of Southern California, 447 p.

Trask, P.D., 1952, Source of beach sand at Santa Barbara, California as indicated by mineral grain studies: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 28, 24 p.

Trask, P.D., 1955, Movement of sand around southern California promontories: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 76, 60 p.

Trask, P.D., 1959, Beaches near San Francisco, California, 1956-1957: U.S. Army Corps of Engineers Beach Erosion Board Technical Memorandum 110, 89 p.

U.S. Army Corps of Engineers, 1953, Coast of California – Carpinteria to Point Mugu, beach erosion control study: 83rd U.S. Congress, first session, House Document 29.

U.S. Army Corps of Engineers, 1962, Coast of southern California – Special interim report on the Ventura area, cooperative beach erosion control study: 87th U.S. Congress, second session, House Document 458, 80 p.

U.S. Army Corps of Engineers, 1962, San Gabriel River to Newport Bay, Orange County, California, beach erosion control study (Appendix 5, Phase 2): 87th U.S. Congress, second session, House Document 602, 167 p.

U.S. Army Corps of Engineers, 1965, Technical report on cooperative beach erosion study of coast of northern California, Point Delgada to Point Ano Nuevo: U.S. Army Corps of Engineers, San Francisco District, Appendix VIII, Contract No. W-04-193-ENG-5196 (4 documents).

U.S. Army Corps of Engineers, 1967, Beach erosion control report on cooperative study of southern California, Cape San Martin to Mexican boundary: U.S. Army Corps of Engineers, Los Angeles District, Appendix VII, Contract No. W-04-193-ENG-5196, 42 p. plus plates.

U.S. Army Corps of Engineers, 1970, Beach erosion control report, cooperative research and data collection program of coast of southern California, Cape San Martin to Mexican boundary: U.S. Army Corps of Engineers, Los Angeles District, Three-Year Report for 1967-1969.

U.S. Army Corps of Engineers, 1974, Hydraulic method used for moving sand at Hyperion Beach erosion project, El Segundo, California: U.S. Army Corps of Engineers, Coastal Engineering Research Center Miscellaneous Paper 4-74, 66 p.

U.S. Army Corps of Engineers, 1985a, Littoral zone sediments, San Diego region, Dana Point to Mexican border: October 1983 - June 1984: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study, CCSTWS 85-11, 152 p.

U.S. Army Corps of Engineers, 1985b, Southern California coastal processes annotated bibliography: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study 85-4, 401 p.

U.S. Army Corps of Engineers, 1986a, Oral history of coastal engineering activities in southern California, 1930-1981: U.S. Army Corps of Engineers, Los Angeles District, 223 p.

U.S. Army Corps of Engineers, 1986b, Southern California coastal processes data Summary: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study 86-1, 572 p.

U.S. Army Corps of Engineers, 1987, Northern California coastal processes annotated bibliography: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study No. 87-5, 491 p.

U.S. Army Corps of Engineers, 1989, San Gabriel River to Newport Beach – Beach replenishment at Surfside-Sunset Beach: U.S. Army Corps of Engineers, Los Angeles District, Geotechnical Report, 5 p.

U.S. Army Corps of Engineers, 1990, Sediment budget report- Oceanside littoral cell:
U.S. Army Corps of Engineers, Los Angeles District.

U.S. Army Corps of Engineers, 1991, State of the coast report, San Diego region:
U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study, Volume 1 - Main Report, Final.

U.S. Army Corps of Engineers, 1993, Existing state of Orange County: U.S. Army Corps of Engineers, Coast of California Storm and Tidal Waves Study, CCSTWS 93-1, Los Angeles District.

U.S. Army Corps of Engineers, 1995, San Gabriel River to Newport Beach – Beach replenishment at Surfside-Sunset Beach: U.S. Army Corps of Engineers, Los Angeles District, Geotechnical Report, 8 p.

U.S. Army Corps of Engineers, 2002a, Silver Strand shoreline, Imperial Beach , California: U.S. Army Corps of Engineers, Los Angeles District, General Evaluation Report, Appendixes A and B.

U.S. Army Corps of Engineers, 2002b, South Coast region (Orange County): U.S. Army Corps of Engineers, Coast of California Storm and Tidal Wave Study, Final Report.

Waldorf, B.W. and Flick, R.E., 1982, Monitoring beach erosion control alternatives – southern California examples: Marine Technological Society and Institute of Electrical and Electronic Engineering, Oceans '82, Ocean Engineering and the Environment, p. 973-979.

Welday, E.E., c1972, The southern Monterey Bay littoral and coastal environment and the impact of sand mining: California Division of Mines and Geology unpublished open-file report to D.J. Everitts, 44 p.

Wiegel, R.L., 1994, Ocean beach nourishment on the USA Pacific Coast: Shore & Beach, v. 62, no. 1, p. 11-36.

Woodell, G.J. and others, 1989, Beach nourishment project compatible with multiple concerns, Santa Monica Bay, California, *in* Magoon, O.T. and others, editors, Coastal Zone '89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 2076-2091.